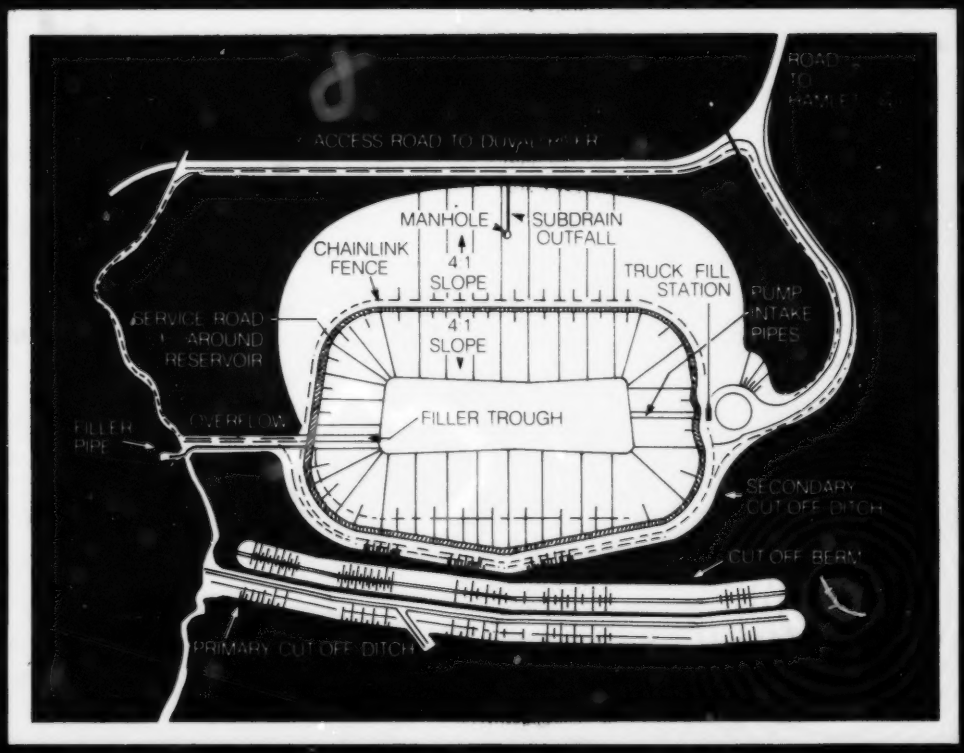
CONSTRUCTION OF THE PANGNIRTUNG WATER RESERVOIR

Northwest Territories, Canada



Northwest Territories

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For presentation to: The Canadian Society for Civil Engineering
— Annual Conference —
Calgary, Alberta
May 23 - 27, 1988

CONSTRUCTION OF THE PANGNIRTUNG WATER RESERVOIR

W.G. Notenboom[1], M. Campbell[1], S. Cheema[2], L.B. Smith[3], R. Douglas[4]

ABSTRACT

This paper discusses the design and construction of the largest in-ground water reservoir in North America, and possibly the world, constructed entirely in permafrost materials. It reviews the design criteria, the considerations into the various construction details and the difficulties encountered during construction. It involved the excavation of 140,000 m^3 of frozen materials, covers an area of 2.8 ha and has a total storage capacity of 120,000 m^3 of water.

The use of local resources was stressed throughout the project. Even though the project is in a remote Arctic community, the local workers made up 67% of the total labour and included heavy equipment operators, truck drivers and labourers.

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PANNIQTUUQ (PLACE OF THE BULL CARIBOU)

The Hamlet of Pangnirtung is located on the southern shore of Pangnirtung Fiord, off Cumberland Sound on Baffin Island. Located just 30 km south of the Arctic Circle, it is well within the continuous permafrost zone. By air, it is 300 km from Iqaluit and it is approximately 2200 km due north from Montreal. (See Figure No. 1).

Cumberland Sound was first visited by Davis in 1585. By 1840, the Sound had become a centre for Arctic whaling and ships began overwintering in the area near Pangnirtung Fiord. A number of small settlements were established and some of the local Inuit became skilled whale boat skippers.

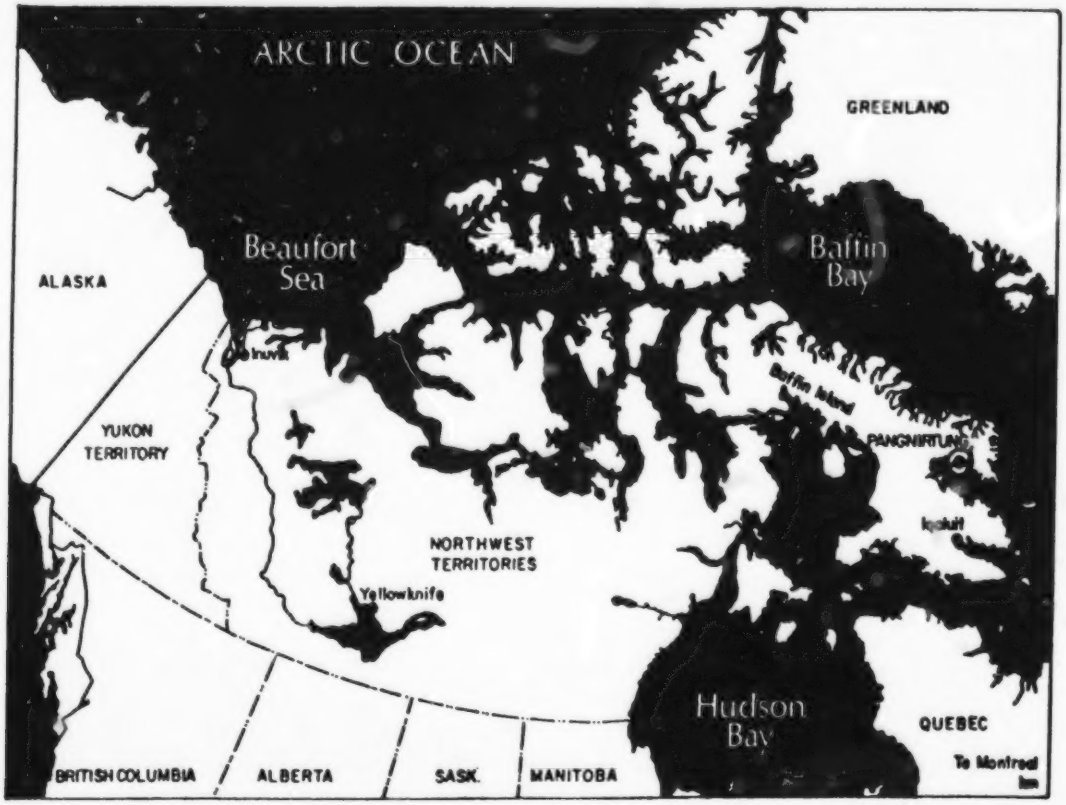


FIGURE NO. 1

By 1910, the whaling industry was in decline and many of the settlements were abandoned. The emphasis had shifted to the fur trade and in 1921, the Hudson Bay Company built a trading post in Pangnirtung. This was soon followed with an R.C.M.P. post, an Anglican Mission, School and Hospital. Until the 1950's, many people lived in outpost camps living from hunting and trapping, coming to Pang only to trade their furs for tools and supplies. In the early 60's, an epidemic wiped out the dog population. Without their dogs, the Inuit lost their mode of transportation and many families moved off the land into the settlement. In 1972, Pangnirtung achieved Hamlet status. Over the years since then, the Hamlet has continued to grow and the present population is approximately 1100 people.

History of Water Supply Development

The Government of the Northwest Territories, through its Water and Sanitation Policy, is responsible for the provision of Water and Sanitation services within the community. Traditionally, the population obtained its water from the Duval River during the summer and from melting snow and ice during the spring and fall. During the winter, once the Fiord was frozen, water was obtained from the Kolik River, located on the north side of the Fiord, directly across from the Hamlet. A distance of approximately 3 miles. With the continued growth of the population, this latter practice was no longer acceptable and in 1968, the first reservoir was constructed. During the summer, the Town still obtained its water from the river, but with the stored water, a more reliable source was available during the winter months for both consumption and firefighting purposes.

The reservoir consisted simply of a 5 metre depression excavated into the permafrost. Unfortunately, the reservoir was located in the Duval River Delta and the soil consisted of boulders, mixed with gravels and sand. Through a combination of an advancing thaw bulb and a very pervious soil, the reservoir leaked badly. As well during the summer and fall, groundwater would leak through the boulder and gravel soil matrix from further up the delta, sometimes half filling the reservoir, and bringing with it large quantities of silt.

In 1976, it was decided to place a liner in the reservoir. At that time, there was little knowledge on the mechanics of permafrost, ice action, movement of water through permafrost, etc. and there were still many problems with the facility. The 30 mil hypalon liner was placed directly on the reservoir subgrade. When the reservoir was filled, the liner would stretch to fill the voids between the underlying boulders. This stretching, combined with chafing over the rough rocks, caused many tears and punctures. Neither was the liner protected and the weight of the ice cover and the chafing on the liner as the water

was drawn down added to the leakage problem. The third major problem was the absence of subdrains. The inflow of groundwater into the excavation continued, lifting the liner and at times, there was more water under the liner than above it. This problem was resolved by building flaps in the bottom of the liner. While it solved the uplift during the summer months, it also added to the leakage problem in the winter.

As well, with the gradual growth of the Hamlet and the increasing per capita consumption, the storage capacity of the reservoir was no longer adequate to meet the consumption demand. In 1980 it was, therefore, decided to carry out a study on either enlarging the existing reservoir or to construct other facilities elsewhere. Among the alternatives investigated were a desalination plant, steel storage tanks, damming of the Duval River and a pipe line or road to a lake, some 10 km up the Duval River Valley. Because of the infiltration problem, it was thought that taliks existed in the old reservoir area and a groundwater supply was also investigated. It was found that these alternatives were either not feasible or not cost effective. The report concluded that in-ground storage was the most cost effective. Three sites were identified for constructing the reservoir; expanding or twinning the existing facility, a site east of the Duval River on the flats along the road to the Hamlet dump or a site also east of the Duval River but higher up on the Mount Duval talus slope.

In 1983, F.J. Reinders and Associates were retained to carry out a pre-design report on the three sites and, based on construction estimates, projected operation and maintenance costs and social impact considerations, recommend and develop a concept for the new reservoir.

Thurber Consultants were retained to carry out a detailed geotechnical investigation on the three sites and to act in an advisory role during the subsequent design and construction phases of the project. Their findings and experience are the subject of a companion paper on the Pangnirtung project.

Site Selection

Among the points considered for the site selection were soil conditions, drainage, haul distance, environmental factors and social impact. From a haulage point of view, the existing reservoir was ideal. Although at one time separate from the residential area of the Hamlet, the housing developments had slowly advanced to the point that the reservoir was on two sides surrounded by homes. (See Figure No. 2).

The soil conditions were not so ideal. As well, the construction would most likely span over several seasons and, since the water supply had to be maintained, enlarging the existing reservoir was not feasible. Due to the slope of the land and economics of construction, twinning of the reservoir would necessitate constructing the second cell at a higher

elevation. As well, because of the leakage and maintenance problems, a complete revamping of the existing facility would be required. Last, but probably one of the most important considerations, was the residential expansion of the Hamlet. The Duval River forms a physical, as well as social barrier, and a residential development east of the Duval River would meet with local opposition. By relocating the reservoir, the existing site and the adjacent lands would become available for development. For these reasons, the existing reservoir site was rejected for the new facility.

The second site on the flats below the Mount Duval slope was attractive with regard to accessibility and haul distance. Located adjacent to an existing road, access construction costs would be minimal. As well, it is feasible to fill the reservoir by gravity from the Duval River. However, drainage of the site is extremely poor and located below the talus slope of Mount Duval, groundwater was expected to be a problem. Ice content of the underlying permafrost soil was quite high and extended well below the proposed reservoir bottom.

With the advance of the thaw bulb below the reservoir, excessive settlement of the bottom would be a distinct possibility. Other points against the site were that the subdrains would not drain by gravity and the site was immediately down wind from the dump. This site was, therefore, also rejected.

The third site was on a level area uphill from site number two. The haul route to this site is longer than that of the other two sites but most of the other problems were either not as severe or non existent. The drainage was better, the high ice content did not extend to the bottom of the reservoir and the boulder content of the soil was not as high.

FIGURE NO. 2

Site number three is separated from site number two by a steep slope. Further investigations concluded that by moving the site further downhill and by selecting a location straddling the steep slope to the flats of site two, the excavation cost would be reduced considerably. The south side of the reservoir would be excavated into the hill and this material would be used for constructing a berm on the flats on the north side. As well, the subdrains could be drained by gravity through a header pipe under the berm to the lower lying flats. After consultation with staff of the Departments of Public Works and Highways and Municipal and Community Affairs, this site was recommended. The findings were presented to the Hamlet Council and basic agreement on the location was reached.

Reservoir Sizing

It is the policy of the Government of the Northwest Territories to design sewage and water facilities for a twenty year horizon. The new facility was, therefore, designed to the projected population and water consumption for the year 2004. At an annual growth rate of 3%, the population for that year will be 1800 persons.

Due to the limited storage capacity and the leaking reservoir, for the last few years a voluntary water conservation program was in operation during the winter months. The actual consumption during this period was only 23 litres/capita/day. As per the territorial design standards, the average consumption should be 112 litres/capita/day; and it was assumed that with an adequate water supply, the consumption will increase to this level. The projected consumption for the twenty year planning horizon is 129 litres/capita/day.

Assuming a worse case scenario, there could be an ice cover on the reservoir for 10 months. The total below ice storage capacity must, therefore, be for a 10 month period and using the projected figures, the storage must, therefore, be 71,000 cubic metres. Based on an ice cover of up to 1.8 metres, only about 60% of the reservoir capacity is available for effective storage.

Reservoir Layout

The reservoir dimensions are 140 X 40 metres along the bottom and 225 X 125 metres along the top. Including a one metre free board allowance, the reservoir depth is ten metres. The reservoir was constructed in the side of a slope between an upper and lower plateau, with the longer dimension parallel to the hill, in an east west direction. (See Figure No. 3).

The truckfill station is located on the east side. The hill is too steep for a truck to climb directly and in order to flatten the slope, the road was constructed in a long sweeping curve. The Duval River is located west of the reservoir and a combination filler trough and overflow weir is located on the west side. A 200 mm diameter line runs above ground from the river to the filler trough. The reservoir is filled with a wheel mounted Gorman & Rupp diesel driven pump, with a capacity of 75 litres/second.

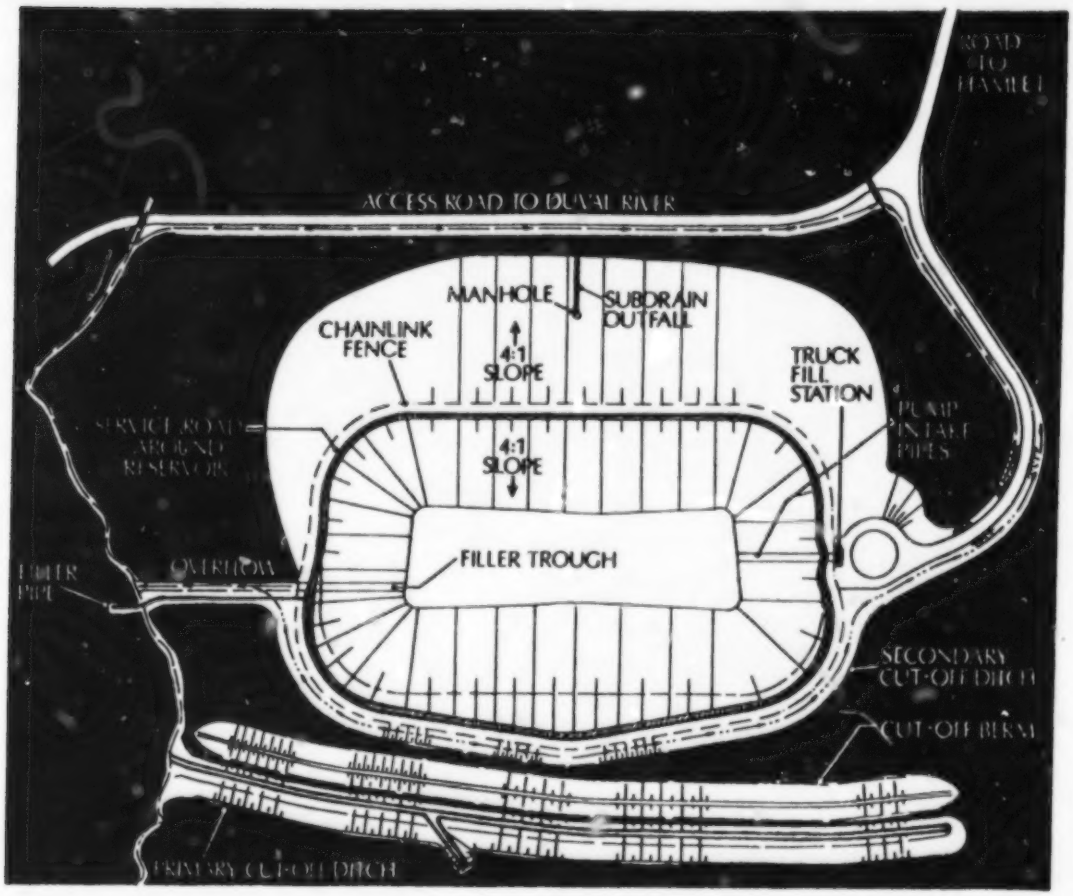


FIGURE NO. 3

The upper plateau starts at the toe of the lower slope of Mount Duval and during the summer thaw, there is a considerable flow of water off this slope. In order to prevent contamination of the reservoir, two cut off ditches were constructed. The first ditch intercepts all the water coming off the mountain and directs it around the reservoir. The permafrost was used to prevent water from leaking through the active layer. The excavated ditch material was used to construct a berm and this berm was insulated with 75 mm styrofoam SM. This prevented the underlying active layer from melting, thereby cutting off the flow of water. (See Figure No. 4).

A second cutoff ditch immediately upstream from the reservoir cuts off any water running off the berm or still seeping through. The perimeter road around the reservoir slopes outward towards the ditch.

For safety reasons and to reduce vandalism, the reservoir is surrounded by a 1.8 metre chain link fence.

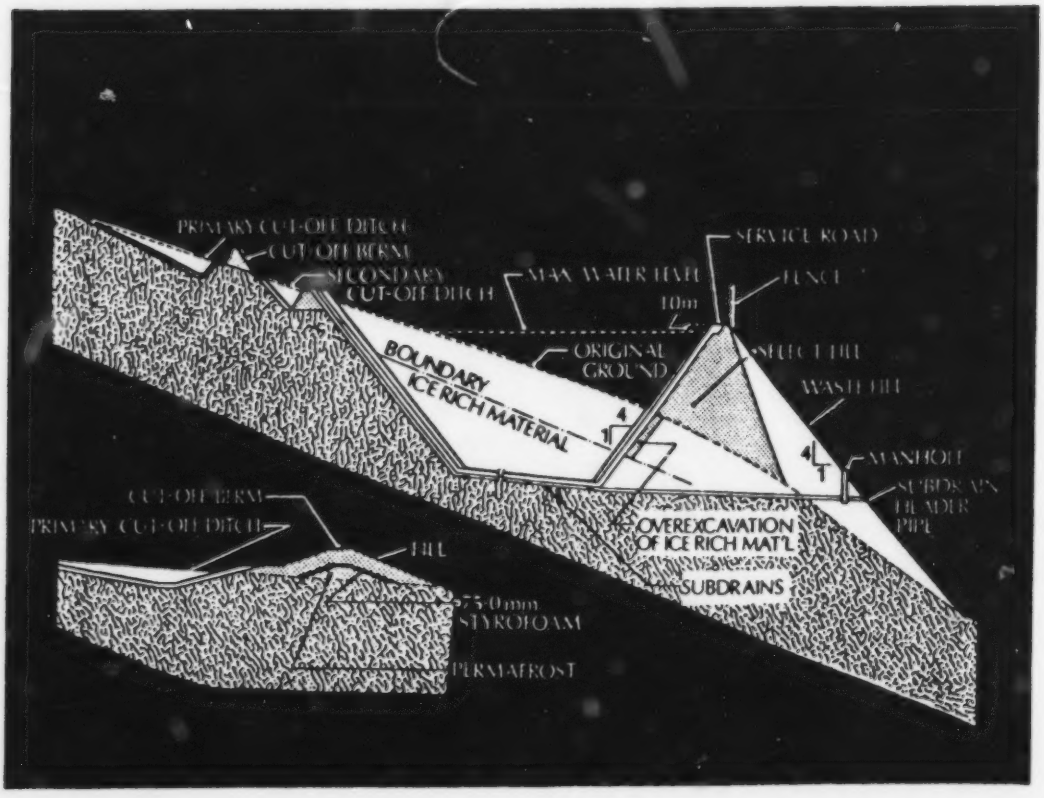


FIGURE NO. 4

Side Slopes

From the findings of the geotechnical investigation, it was realized that with the very silty sand and the relatively high ice or moisture content, it would be difficult to achieve adequate compaction throughout the structure. Also, with the advancing thaw bulb, the fill would lose some of its strength and with steep side slopes, slumping could occur.

Secondly, laboratory tests on the liner material indicated that the cover material over the liner would become unstable at a slope of 3:1 or steeper.

Thirdly, it was recognized that with flatter slopes, the wave erosion of the liner cover material would be minimized.

It was with these considerations that it was decided to construct both the inside and outside slopes of the reservoir to a 4:1 standard.

Details of the placing of the fill, use of different types of fill material is covered in the paper on the geotechnical aspects of the reservoir.

Excavation

As Bruce Smith of Thurber Consultants will explain in his paper, the excavation proved to be a bit more difficult than expected. The ice content of the soil decreases with depth; and while we fully expected that the upper layer would have to be blasted, we had hoped that with depth, the soil would get dryer and, therefore, easier to excavate. Instead, we found that while the ice content was indeed lower, the soil was not any easier to remove.

Excavation had started in November 1985 and had proceeded right through the winter. The thaw was expected to start in June and in order not to get bogged down in mud, it was imperative that the soil with the high ice content be removed by then. This turned out to be more difficult than expected. Firstly, it did not become easier to excavate with depth and secondly, the soil was literally riddled with hundreds of ice lenses. These varied from a few centimetres to up to half a metre.

These ice lenses proved to be very interesting. On the site, the active layer is approximately 1 metre deep and this was quite evident in the soil profiles at the face of the excavation. There was, however, also evidence that the active layer had extended to well over two metres, indicating that at one point, there had been a warmer climate. All the ice lenses were in a horizontal direction in this layer.

Below the active layer, the ice lenses ran in a vertical direction. Some of the larger ones ran right across the reservoir, over 150 metres wide and extended below the bottom of the reservoir, over 10 metres deep.

With the high ice content, it was agreed that the excavation by blasting would extend a minimum of 5 metres, and because of melting and water conditions, this work had to be completed by June 30. The remainder of the excavation would be carried out by summer excavation, i.e. scrape off each days melt, stockpile and remove. In order to complete the blasting work, an additional 100 tonnes of powder was airlifted in and work proceeded in double shifts.

The summer excavation was hampered by an extremely wet summer but by the end of October, the excavation was completed.

Liner

The selection of the liner material was one of the more difficult tasks of the project. Several materials are available and all have both some desirable properties and some characteristics less suitable for a northern application. The items considered were elongation, flexibility at low temperatures, abrasion resistance and joining of materials. Among the materials considered were hypalon, both reinforced and plain, chlorinated polyethylene and high density polyethylene.

After long considerations and several visits to existing facilities, it was decided to use 80 mil high density polyethylene sheeting. This material comes in 6.75 metre wide rolls and is welded rather than glued, making it less susceptible to environmental conditions and resulting in an extremely strong joint.

The welding consists of first joining two overlapping sheets with hot plates and then welding the edge of the top sheet to the bottom sheet with hot extruded polyethylene material. To facilitate the use of automatic welders, all joints ran up and down the slopes, rather than parallel with them. The welders were pulled up the slopes with an electric winch, controlled by the welding machine operator. Collars around pipes, patches, corner joints and other "hard to get to" joints were welded with hand welders. These hand held welders are slower and more difficult to operate but they give the same excellent result.

Quality control was looked after by both a crew from the contractor and a quality control consultant. At the start of each shift and at start of each seam, a weld was run on two pieces of scrap material. Samples were then cut from this material and tested immediately for peel and elongation. The results were usually known within half an hour of the test run. Only in the rare event of a test failure were samples cut out of the actual liner joint. Destructive testing after all, results in many repair patches on the liner and potential leakage problems.

In addition, all joints were tested with a vacuum box for air leaks and with ultrasonic equipment for poor welding joints. Each roll came with a quality control report from the manufacturer, listing punctures, poor welds and thin spots in the liner. Using the report, all deficiencies were noted and repaired.

The welding procedure is very susceptible to wet conditions, and it was a major cause of concern. The contractors crew was, however, quite experienced and well organized and with the help of local labour, the liner was completely installed within a ten day period.

Liner Protection

The lack of liner bedding and protection is, in our opinion, a major cause of liner failure. Both below and above the liner, we specified a 300 mm layer of screened granular material. The material was obtained from the gravel pit and was screened on a power screen equipped with a grizzly and a vibrating screen. The grizzly rejected boulders of 150 mm diameter and over and this material was discarded. For the bedding material, we used a 12 mm size screen. The gravel and stones were stockpiled and the sand collected in trucks and transported to the site. Considered not as critical and in order to speed up production in the very short construction season, for the protective layer above the liner, we substituted a 25 mm screen for the smaller 12 mm one. The rejected gravel was again stockpiled.

After the protective layer was in place, we covered the sand with filter cloth and used the stockpiled gravel for a rip-rap scour protection layer.

The Pangnirtung area is very prone to wind storms and winds of up to 210 km per hour have been recorded. The sand layer would be very susceptible to wave erosion, and the rip-rap will minimize the wave damage. The filter cloth will prevent the mixing of the sand and overlaying gravel.

The cross-section of the liner is shown on Figure No. 5.

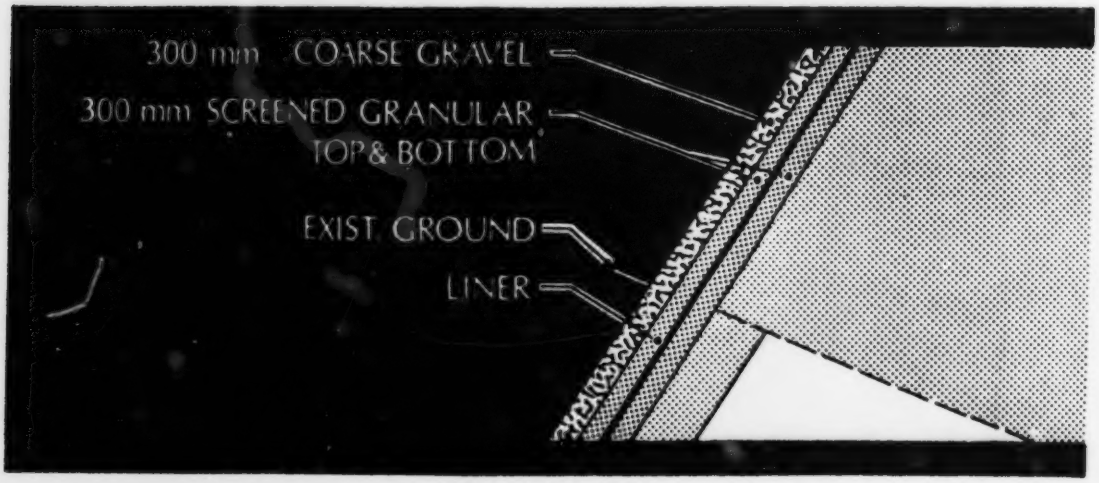


FIGURE NO. 5

Subdrain System

The previous reservoir had clearly proven the need for a subdrain system and an extensive system was placed under the new facility. Perforated 200 mm polyethylene lines were placed both across and length-wise in a 20 X 25 metre grid. (See Figure No. 6). The soil in the reservoir subgrade was found to contain up to 25 percent silt. In order to reduce the chances of the drains silting up, we used two layers of filter cloth. First, we wrapped the subdrains and secondly, we placed filter cloth around the pea gravel bedding and cover.

In the unlikely event of silting or freezing of the subdrains, the lines were run up the reservoir slopes and extended half a metre above the liner. The ends were covered with blind flanges. A pressure sewer flusher is part of the reservoir maintenance equipment, and in the event of a blockage, the lines can be flushed.

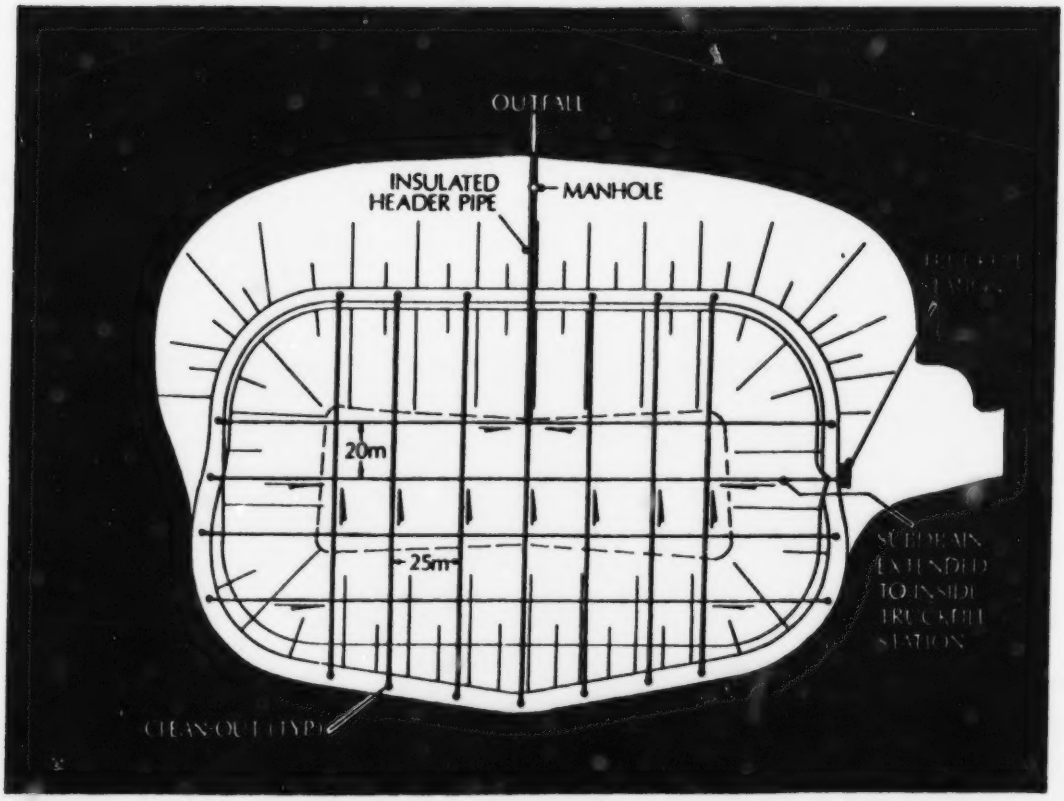


FIGURE NO. 6

The system connects to a header pipe at the centre of the basin. This line drains under the north berm, via a manhole to a ditch. The header pipe drain under the berm is outside the reservoir thaw bulb and was, therefore, insulated and heat traced. In the event of freezing of the outfall, the manhole is equipped with a sump pump as well as heat tracing.

During the harsh winter months, it is difficult to check on the subdrain outfall. One of the subdrains was, therefore, extended up the slope, into the truckfill building. A bubbler line was installed inside the pipe, and it is a simple procedure for the operator to check for water build up in the subdrain system.

Shortly after installation, the system started operating, and it flows at a rate of about 10,000 litres a day. This flow continued at approximately the same rate after the reservoir was filled, and it has flowed right through the winter. As an unexpected check on whether this is groundwater or leakage, it turns out that the groundwater has a slightly salty taste.

Truckfill Station

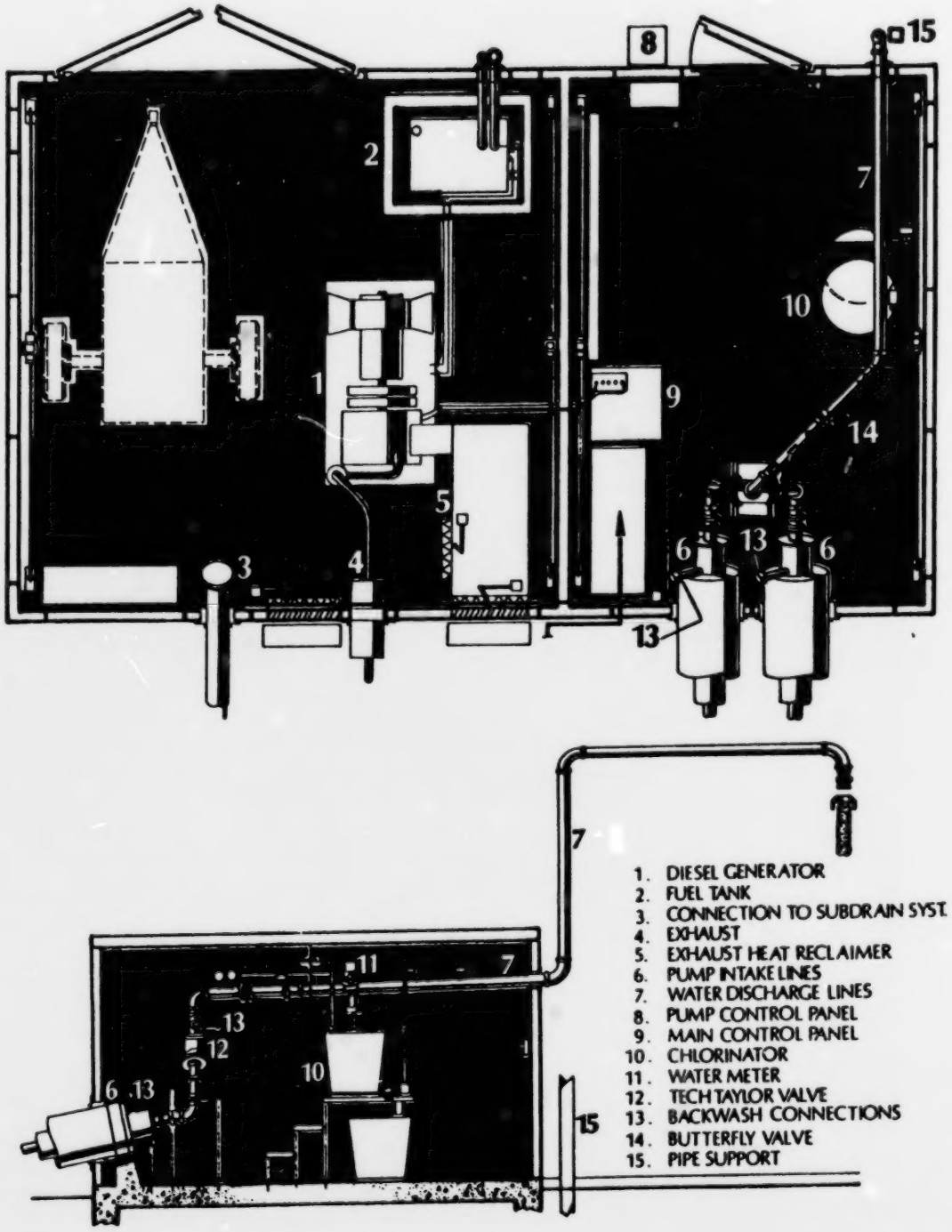
The truckfill station consists of two separate rooms, divided by an insulated wall. (See Figure No. 7). The smaller room is the actual pumping station, and it contains the pump discharge piping, chlorination equipment and control panels. This room is heated at all times.

The second larger room contains the standby diesel generator and storage space for the subdrain flusher and the wheel mounted reservoir filling pump. In order to conserve energy, the heating equipment is connected to a timer and is only activated when required.

The control panel for the pumps is outside and the drivers do not have to enter the building. The pump discharge is preset and shuts off automatically when the truck is filled. If the pump fails, the selector can be switched to the standby pump. The selector switch cannot be turned back until the station operator acknowledges the pump failure.

Water for firefighting is also obtained from the reservoir and a fast turn around for the water trucks is, therefore, essential. The trucks are filled with a cantilevered overhead filler arm. The water is supplied through two Grundfoss submersible pumps, each with a capacity of 1000 litres/minute.

The pumps are located in parallel intake pipes, running from the back wall of the station, down the reservoir embankment to the bottom of the reservoir. There are no check valves on the pumps and the water drains back from the station piping to the reservoir. The control panel has a timed lockout to prevent starting of the pump while the water is draining back through the pump.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15
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11
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10
6
13
15
1. DIESEL GENERATOR
2. FUEL TANK
3. CONNECTION TO SUBDRAIN SYST
4. EXHAUST
5. EXHAUST HEAT RECLAIMER
6. PUMP INTAKE LINES
7. WATER DISCHARGE LINES
8. PUMP CONTROL PANEL
9. MAIN CONTROL PANEL
10. CHLORINATOR
11. WATER METER
12. TECH TAYLOR VALVE
13. BACKWASH CONNECTIONS
14. BUTTERFLY VALVE
15. PIPE SUPPORT

FIGURE NO. 7

Any equipment failure, power outages, low temperatures, etc. trip an alarm. This in turn activates an automatic radio pager and the operator is informed of a malfunction at the truckfill station.

Local/Northern Involvement

In order to stimulate the economy in the Northwest Territories to the fullest extent possible, the Government, through its Department of Public Works and Highways, structures its capital works program in a manner which maximizes employment and business opportunities for local and northern residents. In its contracts, D.P.W.&H. encourages the use of local labour and the use of Northern Subcontractors. With regard to the Pangnirtung contract, the following steps were taken to encourage local involvement in the project.

In his tender, the Contractor was required to list the proposed Northern content. (See Figure No. 8).

Project Number: _____

BUSINESS INCENTIVE FOR NORTHERN CONTRACTORS

The Government of the Northwest Territories has implemented a Business Incentive Policy to promote the use of Northern labour and the purchase of Northern materials, and to encourage the development and competitiveness of Northern business. Information which explains the policy is available from the Department of Government Services.

All Tenderers wishing to apply for a bid adjustment for this Tender, SHALL provide the following information with their Tender. No changes with respect to this information will be allowed without the written authorization of the Deputy Minister. By signing this Tender, the Tenderer is certifying that the contents attributed to Northern Contractors is correct.

NOTE: ALL NORTHERN CONTENT SHALL BE LISTED. This may include the General's portion of the Tender and/or the subcontractor's portion of the Tender. All Northern Contractors must be registered with Government Services, Government of the Northwest Territories.

NAME OF NORTHERN CONTRACTOR	NORTHERN CONTENT 1. AMOUNT ($)
I. GENERAL	
1.	
II. SUBCONTRACTORS	
1.	
2.	
3.	
4.	
5.	
6.	
III. MATERIAL SUPPLIERS	
1.	
2.	

1. The amount listed in this column shall be the total amount of the Northern General Contractor's portion of the Tender and the amount of each Northern Subcontract and Northern Suppliers. If required, substantiation of the above information (copies of Subcontracts) shall be furnished by the Contractor when requested by the Contract Authority.

FIGURE NO. 8

The Hamlet of Pangnirtung, through its Outreach Office, identified the local skills, labourers and services available locally for the construction project. A listing was included in the tender documents. All subsequent hiring was through the Outreach Office. The Contractor was asked to submit in his tender, his proposed use of local/Northern labour and resources. In addition to the tender price, the Contractor selection was based on this proposal. (See Figure No. 9).

Project Number: _____

LOCAL/NORTHERN PROPOSED INVOLVEMENT

In addition to the bid adjustment given under the Business Incentive Policy, it is the intent of the G.N.W.T. that Local/Northern involvement be used to the fullest extent possible on this project. For this reason, Contractors are required to submit the following information with their Tender. This information may be a factor in determining the successful Tenderer; failure to complete this form may result in this Tender being disqualified.

ESTIMATED EXPENDITURE	GENERAL CONTRACTOR		SUBCONTRACTORS	
	$ NORTHERN	$ LOCAL	$ NORTHERN	$ LOCAL
PAYROLL				
MATERIAL				
EQUIPMENT				
TRANSPORTATION				
ACCOMMODATION				
* OTHER				
TOTAL				

* UNDER "OTHER COSTS" PLEASE LIST ANY OTHER LOCAL/NORTHERN INVOLVEMENT ASSOCIATED WITH THIS CONTRACT AS HEREIN DESCRIBED:

_____

_____

PROPOSED TRAINING PROGRAMS: _____

_____

_____

COMMENTS: _____

_____

_____

Note: For the purposes of this form, a Local Expenditure means an expenditure to employees or companies based in the community where the work is to be undertaken.
This form must be submitted either with the Tender or within 24 hours after the Tender closing time.

FIGURE NO. 9

The actual use of local labour and resources was monitored throughout the project (Fig. 10). This program was quite successful and all truck drivers, dozer and loader operators and manual labourers were locals. At the end of the project, the total Northern labour content was 72%. The 28% Southern labour content includes the Contractors supervisory staff and if only the 'labour' component is considered, the Northern content is considerably higher than 72%.

LOCAL/NORTHERN INVOLVEMENT REPORT

PROJECT TITLE: _____ LOCATION: _____

PROJECT OFFICER: _____ PROJECT NO.: _____

CONTRACTOR: _____ PERIOD: _____

EXPENDITURE	GENERAL CONTRACTOR		SUBCONTRACTORS	
	$ NORTHERN	$ LOCAL	$ NORTHERN	$ LOCAL
PAYROLL COSTS THIS MONTH				
EQUIPMENT COSTS THIS MONTH				
PAYROLL COSTS TO DATE				
EQUIPMENT COSTS TO DATE				
MATERIAL COSTS TO DATE				
TRANSPORTATION COSTS TO DATE				
ACCOMMODATION COSTS TO DATE				
*OTHER COSTS TO DATE				

* UNDER "OTHER COSTS" PLEASE LIST ANY OTHER LOCAL/NORTHERN INVOLVEMENT ASSOCIATED WITH THIS CONTRACT AS HEREIN DESCRIBED: _____

COMMENTS: _____

INSPECTOR/ENGINEER - DATE

CONTRACTOR'S REPRESENTATIVE - DATE

FIGURE NO. 10

The Contractor did realize that, even though the listing of the available labour showed trained equipment operators, the experience of these operators would be limited. An instructor was, therefore, brought up as part of the project mobilization. This instructor assisted the local operators for the first few months and instructed them in the efficient use of the equipment. Additional training was provided later on in the project when, due to double shift work, additional operators were required.

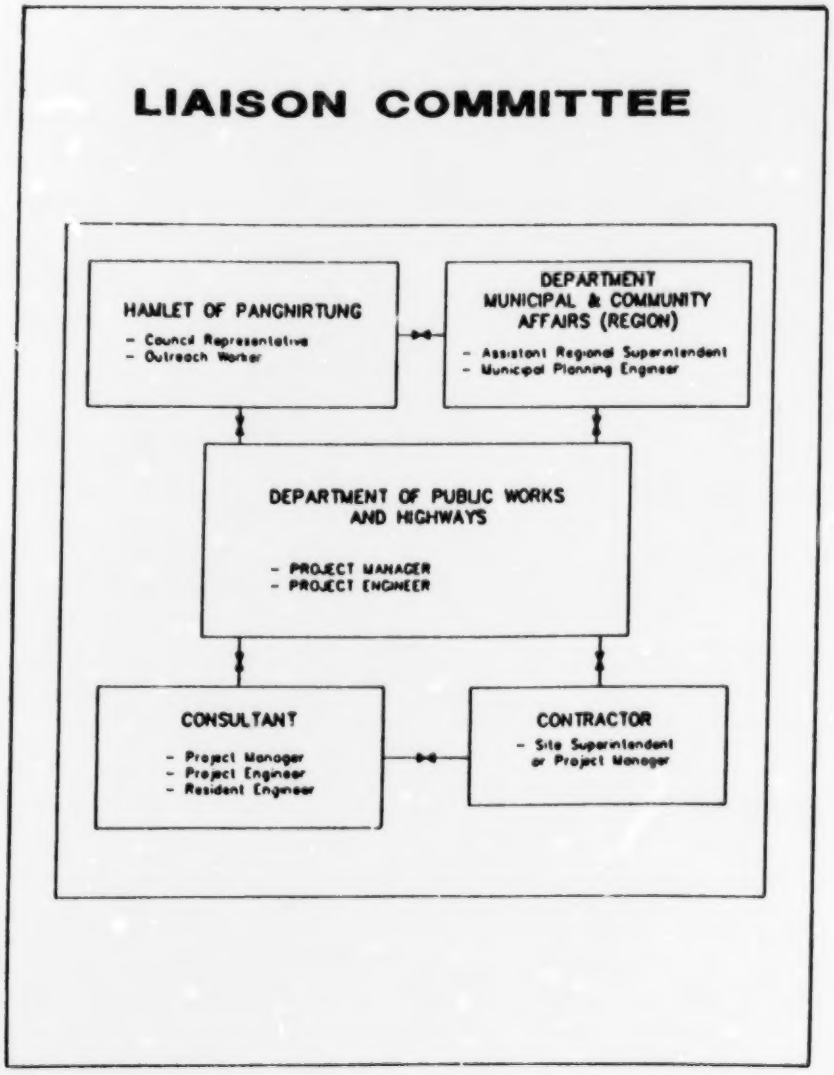

FIGURE NO. 11

Communication with the Hamlet was an important component in the local involvement program. As part of the program administration, a 'Liaison Committee' was set up. This Committee included a Hamlet Councillor, the Hamlet Administrator, the Outreach Worker, the D.P.W.&H. Project Engineer, the M.A.C.A. Planning Engineer, the Contractor and the Consultant's Site Engineer. (See Figure No. 11).

A significant development of the project was the establishment of a private company in Pangnirtung. With the assistance of the Government of the Northwest Territories, the Contractor set up a local equipment leasing company (QIQITAQ Equipment Limited) utilizing the equipment mobilized for the project and maintenance garage/office facilities. Fifty one percent ownership of the company is being made available to local residents and businesses through purchase of shares.

The leasing company was set up at the beginning of the project. All the heavy equipment used on the project was owned by the leasing company and rented out to the Contractor and his Subcontractors.

Project Management

The contract was tendered in April 1985 and awarded in May. By July some preliminary site work was carried out, but work did not begin in earnest until the arrival of the sealift at the end of August. A compound was constructed near the site, complete with heated equipment storage and a fully equipped repair facility. The actual site work did not start until freeze-up and until the frozen tundra crust could support the heavy equipment.

F.J. Reinders supplied the full time construction supervision and the day-to-day project management was carried out on site. There were monthly progress meetings, attended by head office staff from the contractor and consultant, the project engineer from D.P.W.&H. and a representative from M.A.C.A. (See Figure No. 12).

PROJECT MANAGEMENT TEAM

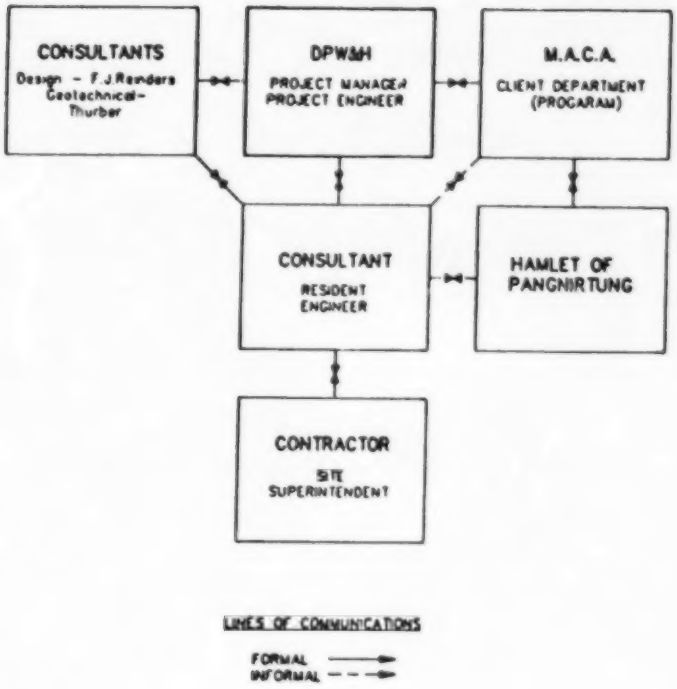

FIGURE NO. 12

Communication is usually a problem with remote sites. This was overcome by using a computer link from the site to the consultant's head office and the D.P.W.&H. project engineer. Weekly reports from the site were transmitted each Monday to the consultant's office and the Yellowknife and Iqaluit D.P.W.&H offices. End of month Progress Certificates would be on the project engineer's desk in Yellowknife on the second or third day of the month.

Acknowledgement

A successful project is generally not due to the efforts of a single person, but rather through the team work of all parties involved. We would like to take this opportunity to thank the staff of the Department of Municipal and Community Affairs, the Hamlet of Pangnirtung and Tower Arctic, the contractor and their subcontractors for their efforts on this project and for a job very well done.